

REMOVAL RESPONSE REPORTS (EPA)

9/23/91 -



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IX

75 Hawthorne Street  
San Francisco, Ca. 94105

TO: DON WHITE, FOB  
TOM MIX, SITE EVALUATION SECTION  
TERRY BRUBAKER, SECTION CHIEF

FROM: ROBERT BORNSTEIN, OSC

DRAFT POST REMOVAL ACTION SUMMARY OF EXPOSURE

SECTION 24

The National Council on Radiation Protection and Measurements (NCRP) Report 91 (1987) recommends the adoption of a limit for continuous or frequent exposure to radiation, at a 100 mrem/yr effective dose equivalent (EDE) from all radiation sources (including external as well as internal sources). The NCRP report also recommends that a limit of 500 mrem/yr be established for infrequent or "short term" exposure. In accordance with the above referenced NCRP guidelines, EPA's Office of Air and Radiation (OAR) has concurred with Region IX's Action Memorandum for the Bluewater Sites, which recommends that a limit of <100 mrem/yr of excess gamma radiation be adopted as a standard in this case, to ensure that the affected population which frequents the mine sites is not exposed to radiation levels in excess of the 500 mrem/yr effective dose equivalent from all sources.

Natural background gamma radiation from all sources in the vicinity of the Bluewater Uranium Mine Sites varies considerably. It may be as low as 12 uR/hr and as high as 20 uR/hr.

For the purpose of this response action, EPA has estimated that the population in question (on average) spends two hours a day in the areas affected by mine operations.

The results of the post removal survey on Section 24 reveal that gamma radiation levels (once exceeding over 500 uR/hr) have been drastically reduced. The average gamma reading within the reclaimed area is presently 28 uR/hr). The highest reading recorded within the survey was 56 uR/hr.

If exposed to 56 uR/hr for 2 hours for 300 days per year, one would receive an excess gamma radiation exposure of 24.6 mrem/yr.

$(56 \text{ uR/hr} - 15 \text{ uR/hr background}) * 2 \text{ hours} * 300 \text{ days/yr} = 24,600 \text{ uR/yr}$  or  $24.6 \text{ mR/yr} = 24.6 \text{ mrem/yr}$

More realistically, the population would be exposed to the average gamma reading of 28 uR/hr and would receive a yearly excess gamma reading of 7.8 mrem/yr.

Therefore, in reclaimed areas, using EPA's estimations, the population frequenting the site will not receive any significant excess gamma exposure. Their excess gamma exposures would not exceed the recommended NCRP recommendation.

Data presented to EPA and calculated by the Navajo Superfund (May 1991) estimates that adult males may spend up to 7 hours a day within the effective mine areas. Using this conservative estimate and the average gamma reading for section 24, the excess gamma radiation for 300 days would be 27.3 mrem/year.

For frequent exposures (long term) the NCRP recommends, populations to not exceed 100 mrem/yr EDE from all sources. With background being approximately 15 uR/hr in the affected area, populations could reside on areas of reclaimed land reading 27 uR/hr or less to adequately stay within this guideline (assuming they are not exposed to other excess radiation sources besides gamma). Approximately 60% of the reclaimed land is potentially suitable for full time occupancy. Additional studies should be conducted within the reclaimed area prior to allowing any homes to be built.

It is unlikely that prior to mining operations, the gamma radiation levels presently being emitted were any lower. Therefore, most likely, portions of the mined area were never suitable for full time occupancy using the NCRP guidelines.

Therefore, the removal action appears to have effectively reduce the potential radiological hazards associated with the abandoned mine operations and has returned the land to a productive environment. No further action should be warranted on this site.

Population frequenting the reclaimed area now can spend up to 24 hours on site for 300 days out of the year or 21 hours per day for 365 days without exceeding the NCRP recommendation for frequent or continuous occupancy of 100 mrem/yr (assuming no additional pathways).

## SECTION 18

The post removal survey conducted on Section 18 on the Brown Vandever site revealed that the average gamma reading was 13 uR/hr. The highest reading was 29 uR/hr. This reading is essentially background and therefore, no additional action should be taken on this section.

Overall, the reclamation project has been extremely successful in reducing the potential radiological hazards at the sites. If you have any questions or comments please contact me at 4-2298.

## Bluewater Abandoned Uranium Mine Site Removal Action A U.S. EPA Superfund Success Story

Stephen M. Dean  
U.S. EPA Region 9 Office of Radiation & Indoor Air

### INTRODUCTION

From August 11 through September 19, 1991, the United States Environmental Protection Agency's Region 9 Superfund Emergency Response Section conducted an emergency removal action at three abandoned uranium mines near Bluewater, New Mexico (Figure 1). The removal action was a major success and accomplished three goals: First, it greatly reduced the health threat to the local residents. Second, it helped establish a clean up standard for other mine reclamation projects in the area. And third, it motivated the U.S. EPA Superfund Program to establish a procedure for characterization and remediation of open pit uranium mine sites.

On November 21, 1990, the Agency for Toxic Substance and Disease Control Registry (ATSDR) issued a health advisory stating that abandoned uranium mine sites known as Nanabah Vandever, Brown Vandever and Desiderio mines posed an "imminent and substantial risk" to members of Navajo Reservation homesteads located nearby. The public health advisory cited the following:

1. Physical hazards which included open pits, open mine adits and ventilation shafts, all accessible by children.
2. Excessive gamma radiation exposure from mine tailing and proto ore piles.
3. Potential leaching of heavy metals into the groundwater.

This advisory was a result of Navajo Superfund Program's request to ATSDR for assistance in determining the risk to life and health for residents living near the abandoned mines. ATSDR established that an imminent and substantial risk did indeed exist for the inhabitants.

Once a health advisory was issued the U.S. EPA Region 9 Superfund Emergency Response Section (ERS) assumed responsibility for mobilizing an emergency removal action at this site. Since it had limited experience with radiation contaminated sites ERS requested support from the U.S. EPA Headquarters, Office of Radiation Programs (HQ ORP), Office of Radiation Programs - Las Vegas Facility (ORP-LVF), and U.S. EPA Region 9 Office of Radiation and Indoor Air (ORIA) for radiation support. In a combined effort they proceeded to: 1) characterize the site for potential radiation hazards; 2) perform risk assessment for the site targets; 3) mobilize removal action resources; 4) conduct a pre-removal action site characterization; 5) conduct a post removal action site survey including soil sampling and analysis.

BLUEWATER ABANDONED URANIUM MINE SITE

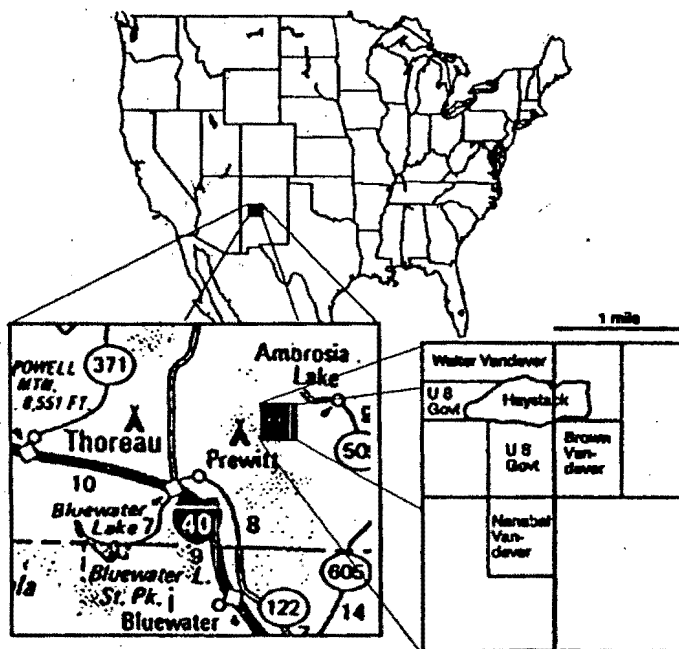


FIGURE 1.

## SITE DESCRIPTION

While the Bluewater site is not geographically located in U.S. EPA's Region 9, this Region has the responsibility for working with the Navajo Nation on all environmental issues affecting Navajo Reservation land.

The site is located 80 miles west of Albuquerque near Prewitt, NM and is an aggregate of three mines; Nanabah Vandever (Section 24), Brown Vandever (Section 18), and the Navajo Desiderio Mine. The most prominent feature in the area is Haystack Mountain, considered by the Navajos to be a sacred burial site.

Both Brown Vandever and Nanabah Vandever are open pit and strip mines located at the southeast base of Haystack Mountain. The Desiderio mine is approximately three miles to the southeast of the mountain. All are located at elevations of between 6,500 to 7,000 feet in semi-arid terrain.



**FIGURE 2. An abandoned open pit uranium mine near homes.**

The site is inhabited by extended Navajo family homesteads. About 40 people live within one half mile of Sections 18 and 24. These sections encompass 155 acres with 50 acres seriously impacted by mine activities.

The Navajo Desiderio Mine is 130 acres with 30 acres seriously impacted. Approximately 30 people live within one quarter mile of the site (Figure 2) and half of the inhabitants are children. In addition to open pit and strip mining, some shaft mining (Figure 3) was also conducted at here.

## PRE-REMOVAL PREPARATION

Usually, Superfund ERS mobilizes immediately once a health advisory has been issued. However, as soon as ERS began its investigation it encountered numerous legal questions and bureaucratic obstacles. Major questions had to be answered such as: Was Superfund overstepping its authority by taking emergency response action on abandoned uranium mines?

Or, by doing this action would Superfund become legally liable for the clean up of the other 7,000 uranium mines in the United States?

Besides sorting out the regulatory issues of uranium mine oversight, identifying the potentially responsible party (PRP) was also a difficult issue. Some of the mine tracts were owned by the federal government, some by mining companies, some by private citizens and some by the Navajo Reservation. Who would be responsible for the clean up costs?

It took the ERS six months to get concurrence from the various regulatory agencies and to determine the PRP for each mining section of the site. Other federal agencies involved included: Bureau of Indian Affairs (BIA), Bureau of Land Management (BLM), Department of Interior (DOI), Navajo Superfund, Indian Health Services (IHS), ATSDR, and the EPA's own legal counsel. After an ongoing dialogue eventually all parties agreed that the EPA ERS would provide the fastest response to the health advisory.

DOI had insisted that uranium mine reclamation was under its regulatory authority, and therefore, it would do the response action. However, on August 5, 1991, DOI informed Region 9 ERS that it would be unable to proceed on the

Bluewater Site unless it could acquire special funding from Congress. ERS felt it had postponed its response long enough waiting for another agency to take the lead. Therefore, on August 6, 1991, it decided to proceed with a response action and began mobilizing immediately.

### PRE-REMOVAL SITE CHARACTERIZATION

Another major problem was designing a removal action based on the information collected by ATSDR during their preliminary investigation. The site characterization data was incomplete and the radiological assessment was inconclusive. Analysis of well water samples taken at the homesteads showed that heavy metals left by mining activities had not leached to groundwater, but, numerous piles of proto (low grade) ore, as well as, mine overburden showed elevated gamma activity. While ATSDR had determined that these piles posed a threat it had not quantified the amount of radioactive material present in a manner that offered a practical removal strategy.

The Emergency Response Section with the assistance of the Office of Radiation and Indoor Air began a thorough site assessment on August 12, 1991. The

Bluewater Site Assessment Team consisted of 5 members:

Robert Bornstein; ERS On Scene Coordinator; Art Ball, Environmental Response Team (ERT) Health Physicist, Steve M. Dean, ORIA Environmental Scientist; Jerry Gels and Ken Munney, both Weston REAC contractors.

First, the team established that the background for the undisturbed areas surrounding the mines averages from 12-15 microRoentgens/ hour ( $\mu\text{R/hr}$ ). One survey, however, was able to find some undisturbed limestone outcroppings with waist high (1 meter high) readings of up to 50  $\mu\text{R/hr}$ . Team members used Ludlum 19 survey meters calibrated for radium by ORP-LVF to measure the external gamma levels.

Next, the team laid out a 50 feet x 50 feet grid pattern over the entire disturbed area of Sections 24 & 18. After the grids were established the team surveyed the areas by recording both the waist high and ground level gamma readings at each node in each grid.

The waist high measurements were entered into a spreadsheet using Lotus 123™ on a laptop personal computer. Each grid node was assigned a cell in the spreadsheet and the appropriate measurement entered. A spreadsheet file for each site was then loaded into a program named Surfer™. Surfer converted the data from each site into a Surfer contamination contour map or a SCCM for each site. The contours of each SCCM were based on gamma activity, not on the actual topographical features. A blueprint for an effective clean up strategy at each site was generated by comparing each SCCM with an aerial photograph of its respective mine site.

Each SCCM made it relatively easy to match up the contaminated mounds of mine tailings with the pits from which they probably came. They clearly revealed the areas with high and low gamma readings. It became easy to identify which mounds were proto ore with the highest gamma readings, which were mine tailings with readings well above background, and which were overburden with background readings. Proto ore piles tended to show up as hot spots. The SCCM of Section 24 (see Figure 4) revealed two hot spots of 1250  $\mu\text{R/hr}$ . The two areas reading 250  $\mu\text{R/hr}$  were pits dug to the limestone bedrock. The SCCM for Section 18 (see Figure 5) had one hot spot of 750  $\mu\text{R/hr}$ , this again was a pile of proto or low grade ore. The area of 240 to 340  $\mu\text{R/hr}$  was a pit.



FIGURE 3. Superfund staff inspecting an open mine adit.

Establishing the 50' x 50' grids, taking the radiation readings and then generating the SCCMs at all three sections took the team almost two weeks but the results were extremely useful.

## THE REMOVAL ACTION

The Superfund ERS contracted the Laguna Construction Company to do the actual removal action. The Laguna Construction Company was established by the Bureau of Indian Affairs and the Pueblo of Laguna to reclaim the Jackpile Mine, the world's largest open pit uranium mine. The Company has an outstanding record in uranium mine

PRE-RECLAMATION  
NANABAH ALLOTMENT (SEC. 24, T13N, R11W)

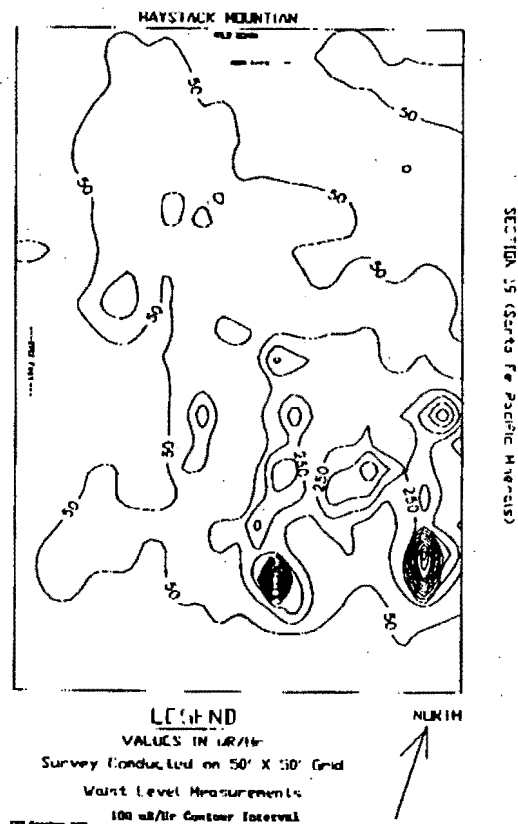


FIGURE 4. Section 24 Pre-Removal Action SCCM.

PRE-RECLAMATION  
BROWN-VANDEVER ALLOTMENT (SEC. 18, T13N, R10W)

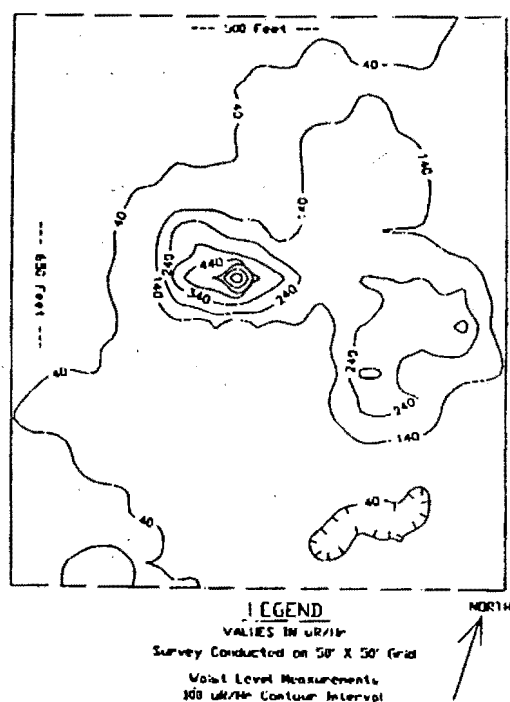


FIGURE 5. Section 18 Pre-Removal Action SCCM.

reclamation. Laguna Construction was a logical choice for this project for several reasons: The company enjoys an excellent track record and its personnel are familiar with the regional geology and topography. EPA felt it was appropriate to use a wholly owned Native American company to remediate Native American land.

On August 19, 1991, the Laguna Construction Company arrived on site. The heavy equipment consisted of three Cat D-9N dozers, one Cat D-6N dozer, one Cat 14G grader, and one Cat 980C front end loader. Support equipment included a fuel truck, a mechanics truck, and an office trailer which served as an office and lunch room. All the earth moving equipment was outfitted with environmentally controlled cabs with hepa filtration systems to insure that the operators would not inhale or ingest radioactively contaminated fugitive dust caused by the remediation. Health physics support was provided at the site throughout the entire remediation and access to the area was restricted while being worked.



Each Section was worked until it was consistent with the surrounding terrain. Next it was extensively surveyed with Ludlum 19 survey meters by the health physics staff. Any area that gave a reading of over 50  $\mu\text{R/hr}$  (equal to the highest natural background reading found) was reworked until the gamma reading was 50  $\mu\text{R/hr}$  or less.

Laguna Construction did an excellent job of returning the disturbed areas to a more natural contour. All pits were filled, all open adits were covered. Special attention was paid to insure that the graded areas would have the proper water runoff. No clean topsoil or fill was brought to, nor was any contaminated material taken from the site. The entire removal action was done with just the existing materials; proto ore, mine tailings, and overburden that had been left behind at the mine sites. Also special attention was given to preserving the existing pinyon and juniper trees on the periphery of the disturbed areas. Some of these trees are over one hundred years old and will contribute to reseedling the graded areas. Laguna Construction completed its phase of the removal action on September 18th after just four and one half weeks.



FIGURE 6. The view from Figure 2 after the removal.

#### POST REMOVAL ACTION SITE CHARACTERIZATION

After the heavy earth moving and grading was completed, new grids were laid out on each section. Waist high gamma readings were again taken at each grid node. These readings were used to generate a new SCCM for each section. Section 24 revealed gamma readings averaging 24  $\mu\text{R/hr}$  with a maximum of 50  $\mu\text{R/hr}$  (see Figure 7). Section

POST RECLAMATION  
NONABAH ALLIEMENT (SEC. 24, T13N, R10W)

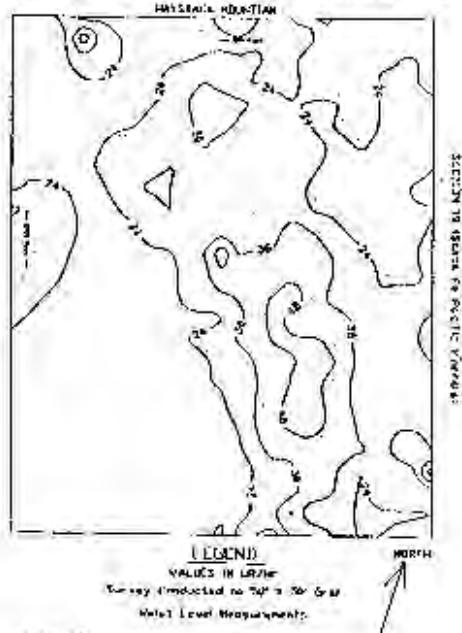


FIGURE 7. Section 24 Post Removal Action SCCM.

POST RECLAMATION  
BROWN VANTILVER ALLIEMENT (SEC. 18, T13N, R10W)

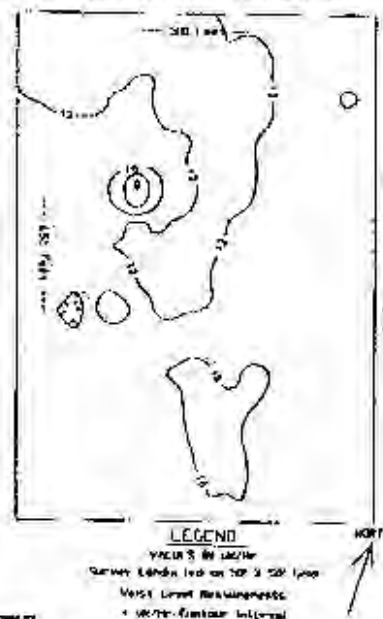


FIGURE 8. Section 18 Post Removal Action SCCM.

18 revealed readings between 12 to 16  $\mu\text{R/hr}$ , this section was essentially remediated to background (see Figure 8). Most of the Desiderio site measured 12  $\mu\text{R/hr}$  with several small area reading 24 to 36  $\mu\text{R/hr}$ . Unfortunately, the records of the pre-mining surveys for these mines have been lost. Yet still, it is reasonable to suppose that the entire site was remediated to background. Most of the radioactive materials had been removed during mining operations years earlier.

A sampling team collected composite soil samples at each section to insure that residual uranium and radium 226 would not pose threats to the surrounding population. Due to their size, Section 24 and Desiderio were each subdivided into three sampling plots (A, B, & C). Ten samples were collected in all; three composites from Section 24 plus one composite background, one composite from Section 18 plus one background composite, and three composites from Desiderio plus one background. These samples were analyzed for radium 226 and total uranium by the U.S. EPA's National Air and Radiation Environmental Laboratory (NAREL) in Montgomery, Alabama. The results are listed below.

**TABLE 1. Soil Analysis Results for Total Uranium and Radium 226.**

<b>SAMPLE ID</b>	<b>Total Uranium (pCi/g)</b>	<b>Radium 226 (pCi/g)</b>	<b>Yield</b>
NV Sect 24A	7.0	3.7	103%
NV Sect 24B	3.6	3.2	97%
NV Sect 24C	3.2	2.9	96.6%
NV 24D Background	0.55	0.73	98%
NV 24D Background (duplicate)	0.64	0.90	96%
BV Sect 18A	1.5	0.94	99.9%
BV Sect 18B Background	0.97	0.93	90%
DES 1	2.9	1.8	89%
DES 2	3.5	3.6	99.8%
DES 3	2.3	1.7	69.9%
DES 4 Background	2.2	2.4	111%

NCRP Reports 45 & 94 give the typical soil values in the U.S. for total uranium as 0.5 to 1.5 pCi/gram and for radium 226 as 0.5 to 1.0 pCi/gram. Total uranium concentrations of less than 30 pCi/gram and radium 226 concentrations of less than 5 pCi/gram for the first 15 centimeters are considered acceptable for uranium mill tailing remediation under 40 CFR 192.

While Section 24A has the highest total uranium, radium 226, and external gamma readings, the values for each are acceptable. It should also be noted that this plot is located the farthest away from any of the homesteads and in the most remote area.

## COST OF THE REMOVAL ACTION

The table below is a break down of this removal action's total cost. The total cost of this removal action ran just 53% of the Budget Ceiling because of the cost savings from eliminating the need for purchasing clean fill and its associated hauling costs. The average cost per acre calculated out to about \$4,000 per acre remediated.

**Table 2. The Removal Action Expense Breakdown**

<b>Budget Ceiling</b> .....	<b>\$630,000</b>
Laguna Construction Company .....	234,000
EPA Overhead .....	62,500
EPA Contractors .....	36,500
<b>Actual Expenses</b> .....	<b>\$333,000</b>

While ERS views the total cost per acre as quite reasonable when compared to other sites, Superfund is pursuing cost recovery for this action from the Department of Interior.

### SUMMARY

The Bluewater Abandoned Uranium Mine removal action was a success for U.S. EPA Region 9. The three key factors that contributed to this success can be summarized as follows:

1. The project was undertaken as an emergency removal action by the Regional Superfund Emergency Response Section. This bypassed much of the bureaucratic overhead that would be required to get this site ranked on the National Priorities List. The ranking process alone could take several years, ERS was able to complete the remediation in less than ten months after ATSDR issued its health advisory.

2. The second key factor was the use of an effective site characterization strategy. The taking of waist high (1 meter high) gamma readings and using the nodes of a 50' x 50' grid for reference points, and then entering the data into a computer program that converted the data to contamination contour maps was absolutely essential for obtaining outstanding results.

3. The third key was the Laguna Construction Company. The company's experience with uranium mine reclamation as well as its knowledge of the geology and topography of the region was invaluable for insuring a quick and thorough removal action.

For more information about this site contact Stephen M. Dean, U.S. EPA Region 9, Office of Radiation and Indoor Air (A-1-1), 75 Hawthorne Street, San Francisco, CA 94105, (415) 744-1045.

† Surfer is a registered trademark of Golden Software, 807 14th Street, P.O. Box 281, Golden, CO 8002, (800) 972-1021.

†† Lotus 1-2-3 is a registered trademark of Lotus Development Corporation.

## REFERENCES

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IX

75 Hawthorne Street  
San Francisco, Ca. 94105

September 23, 1991

MEMORANDUM

SUBJECT: Bluewater Uranium Mine Sites, Prewitt, New Mexico

FROM: Robert Bornstein, OSC *MB*  
USEPA-ERS

TO: Bluewater Interagency Members

Enclosed is a summary of the results of our response actions at the Bluewater Uranium sites. If you have any questions, please contact me at 415-744-2298.



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IX

75 Hawthorne Street  
San Francisco, Ca. 94105

POST REMOVAL ACTION SUMMARY OF EXPOSURE  
FINAL DARFT  
September 20, 1991

The Environmental Protection Agency has completed response activities at the Bluewater Uranium Mine Sites located outside of Prewitt, New Mexico. The response activities were conducted to reduce the potential radiological hazards associated with the sites. As a result of previous mining activities and absence of reclamation action, the sites contained large open pits with exposed uranium bearing tailings, protore and tailing piles.

To reduce the potential radiological hazards associated with the sites, EPA conducted the following actions:

- \* Filled, graded and applied an earth cover to areas emitting elevated gamma radiation;
- \* Filled, sealed and capped mine adits, inclines and shafts;
- \* Posted warning signs on site to advise people to not disturbed reclaimed areas;
- \* Revegetated affected zones with natural grasses.

Response actions commenced on August 11, 1991. Detailed radiological surveys were conducted at the sites to further delineate areas of concern. On August 19, 1991, Laguna Construction mobilized on site and began earth moving activities. Laguna Construction completed its activities on September 18, 1991.

RESPONSE RESULTS

The National Council on Radiation Protection and Measurements (NCRP) Report 91 (1987) recommends the adoption of a limit for continuous or frequent exposure to radiation, at a 100 mrem/yr effective dose equivalent (EDE) from all radiation sources (including external as well as internal sources but excluding natural background and medical exposures). The NCRP report also recommends that a limit of 500 mrem/yr be established for infrequent or "short term" exposure. In accordance with the above referenced NCRP guidelines, EPA's Office of Air and Radiation (OAR) has concurred with Region IX's Action Memorandum for the Bluewater Sites, which recommends that a limit of <100

mrem/yr of excess gamma radiation be adopted as a standard in this case.

Natural background gamma radiation from external sources in the vicinity of the Bluewater Uranium Mine Sites varies considerably and is dependent upon local geology. It may be as low as 12 uR/hr in areas lacking natural uranium deposits and as high as 20 uR/hr in areas containing uranium rich ore. Naturally exposed uranium rich Todilto limestone outcrops at the Desiderio Mine Site recorded readings as high as 50 uR/hr at waist level.

For the purpose of this response action, EPA has estimated that the population in question (on average) spends two hours a day for 300 days/yr in the areas affected by mine operations. A more conservative estimate of 7 hours a day was given to EPA by the Navajo Superfund Program in May of 1991.

#### BROWN-VANDEVER-NANABAH SECTION 24

A 50 foot by 50 foot grid survey was conducted at the Brown-Vandever-Nanabah sites. The results of the post removal survey on Section 24, Township 13N, Range 10W of the Bluewater Quadrangle (Brown-Nanabah site) reveal that gamma radiation levels (once exceeding 500 uR/hr in places) have been drastically reduced. The average gamma reading within the reclaimed area is presently 28 uR/hr. The highest reading recorded within the survey was 56 uR/hr. In addition to reducing gamma radiation emissions, the covering of the protore and mine wastes most likely has reduced the surface radium and other radionuclide concentrations in the top 15 cm of soil (post analytical results are pending), as well as radon flux.

Using the average gamma reading, the population would receive a yearly excess gamma radiation dose of 7.8 mrem/yr. This compares to the average annual background radiation dose received in the United States of 300 mrem/yr as reported by the NCRP.

$$(28 \text{ uR/hr} - 15 \text{ uR/hr}) * 2 \text{ hours} * 300 \text{ days/yr} = 7800 \text{ uR/yr}$$
$$7800 \text{ uR/yr} = 7.8 \text{ mR/yr} = 7.8 \text{ mrem/yr}$$

Using the conservative estimate of 7 hours a day and the average gamma reading for section 24, the excess gamma radiation for 300 days would be 27.3 mrem/year. This exposure is also well below the NCRP standards.

Therefore, in reclaimed areas, using EPA's estimations, the population frequenting the site will not receive any significant excess gamma exposure. Their excess gamma exposures would not exceed the recommended NCRP recommendation.

For frequent exposures (long term) the NCRP recommends,

populations to not exceed 100 mrem/yr EDE from all sources (excluding natural background and medical sources). With background being approximately 15 uR/hr in the affected area, populations could reside on areas of reclaimed land reading 27 uR/hr or less to adequately stay within this guideline (assuming they are not exposed to other excess radiation sources besides uranium chain gamma). Approximately 60% of the reclaimed land is potentially suitable for full time occupancy. These are very conservative calculations because no credit is taken for the shielding effect of the home on any increases in terrestrial radiation.

Additional studies should be conducted within the reclaimed area prior to allowing any homes to be built. However, it is highly unlikely that prior to mining operations, the gamma radiation levels presently being emitted were significantly lower. It is probable that some portions of the strip-mined area were naturally higher than the average background elsewhere as a result of the proximity to the surface of uranium-rich ore.

Therefore, the removal action appears to have effectively reduced the potential radiological hazards associated with the abandoned mine operations and has returned the land to a productive environment. No further action should be warranted on this site.

Population frequenting the reclaimed area, on average, can spend up to 24 hours on site for 300 days out of the year or 21 hours per day for 365 days without exceeding the NCRP recommendation for frequent or continuous occupancy of 100 mrem/yr (assuming no additional pathways, ERS/OAR has collected post removal soil samples and is presenting analyzing them for their radionuclide activity). Prior to mining operations, it is unlikely that gamma radiation readings were significantly lower than those achieved after reclamation.

#### BROWN-VANDEVER SECTION 18

The post removal survey conducted on Section 18, Township 13N, Range 10W of the USGS Bluewater Quadrangle (the Brown Vandever site) revealed that the average gamma reading was 13 uR/hr. The highest reading was 29 uR/hr. This reading is essentially background and therefore, no additional action should be taken on this section.

#### DESIDERIO MINE SITE

A post removal survey using a 100 foot by 100 foot grid was conducted on the top 15 acre portion (Starting at the residences and heading due east) at the Desiderio site (Section 26, Township 13N, Range 10W). This survey revealed that the average gamma reading within the reclaimed area was 15 uR/hr. A random survey was conducted on the other reclaimed areas near the road, the once far southern pits, and the old shaft areas. Values ranged from a high of 50 uR/hr to a low of 15 uR/hr. The average reading in



these isolated locations is approximately 28 uR/hr.

Like the Vandever sections, the post removal results at the Desiderio site reveal that the gamma emissions (once exceeding 700 uR/hr in places) have been drastically reduced. Levels present at the site are well within reclamation guideline levels and pose no significant health risks for long term exposures. It is likely that the reclaimed gamma emissions are no greater than those detected prior to mining operations at all three reclaimed sections (Readings of 50 uR/hr were detected on unmined naturally occurring Todilto limestone outcrops).

Overall, the reclamation project has been extremely successful in reducing the potential radiological hazards at the sites.

SUMMARY CONCERNING HOME RADON  
Composed by Jerry Gils, Health Physicist, REAC

Strip mining operations occurred at both of the Bluewater Uranium Mine Sites in the past, indicating that relatively rich uranium deposits lie fairly close to the surface and in close proximity to the home sites. Two questions need to be answered at these locations: (1) How do indoor concentrations measured at these two sites compare with concentrations measured elsewhere? And, (2) Is it either likely or possible that past mining operations have adversely affected the radon concentrations indoors?

To answer the first question, it has been reported that a concentration of 4.6 pCi/L has been measured at one of the homes at the Desiderio Site, as well as concentrations between 1.5 and 3.3 pCi/L at other homes on site. These measurements were taken with alpha track detectors left in place for two to three months. The results reported at the mine sites are typical for this area (IHS survey, January, 1990,) and in most areas of the country. In the immediate Bluewater area, thirteen homes were measured in the IHS survey, ranging from <1.0 to 7.5 pCi/L, with the average being 2.5 pCi/L. As another point of comparison, a survey in North Dakota showed average radon concentrations of about 6 pCi/L. The conclusion is that there seems to be nothing unusual about the results reported at the two mine sites.

Is it likely, or even possible, that past mining operations have affected indoor concentrations at these sites? The source of indoor radon is the soil in direct proximity to the home. The distance that radon can travel before it decays is directly related to the soil porosity and inversely related to the moisture content. The two mine sites contain a soil horizon composed of fine to coarse grain sand and weathered limestone. The soil porosity is high and the moisture content is low. Therefore, the soil possesses very good soil gas diffusion characteristics. However, since the mean diffusion path length for a radon atom is only a few meters at most before it decays,

and since no mining operations have taken place within 50 meters of any on the homes, it is unlikely that the mining operations have in any way affected the soil gas radon concentrations near the homes.

Since these two sites are not "normal" sites as far as the potential for outdoor concentrations of radon, the additional question might be asked, "Could these homes be affected by airborne radon from nearby exposed uranium seams or open mine shafts?". It is difficult to answer "No" to such a speculative question, since outdoor concentration measurements have never been made to my knowledge. However, it is very unlikely that increases in outdoor concentrations near the homes have occurred as a result of mining operations. The distance of the homes from any potential airborne sources plus the vast volume of mixing air between source and receptor support this conclusion. Indirectly, it must be noted that while radon soil gas measurements have been used as a prospecting tool, radon air concentration measurements have never been used to prospect for uranium. This indicates that increased air concentrations are not associated with rich uranium soil deposits, and thus one would not expect to see any increase in airborne radon concentrations near the homes on these sites.

In conclusion, it does not appear that any "mining enhanced" increased indoor radon concentrations should be expected or have been measured at the homes on the Vandever and Desiderio sites. Additional long-term measurements following EPA protocols may help clarify this conclusion. It is recommended that any new home construction, particularly on land included as part of this removal action, include piping and sub-foundation gravel consistent with EPA recommendations for new home construction, so that if elevated concentrations are encountered (as have been in 8.3% of the homes in the IHS study), mitigation procedures will be cheap and effective.